REMARKS

The rejection of: **(1)** claims 13, 16, 19, 23, 25, and 26 under 35 U.S.C. § 103(a) over U.S. Patent No. 6,469,448 ("Taguchi") in view of U.S. Patent No. 6,280,563 ("Baldwin"), JP 2000-355771 ("Okabe"), U.S. Patent Application Publication No. 2003/0168172 ("Glukhoy") and U.S. Patent Application Publication No. 2003/0183169 ("Ueda"), **(2)** claim 17 under 35 U.S.C. § 103(a) over Taguchi in view of Baldwin, Okabe, Glukhoy and Ueda and further in view of U.S. Patent No. 5,975,013 ("Holland") or U.S. Patent Application Publication No. 2004/0020432 ("Takagi"), and **(3)** claims 21 and 22 under 35 U.S.C. § 103(a) over Taguchi in view of Baldwin, Okabe, Glukhoy and Ueda and further in view of U.S. Patent No. 6,390,019 ("Grimbergen"), are respectfully traversed.

The present invention relates to a plasma processing apparatus for treating an object with plasma. The apparatus is configured to supply radio-frequency power into a process chamber to generate the plasma.

As recited in independent claim 13, the apparatus comprises a top plate which is disposed opposite to the object to be processed through the medium of a region for generating the plasma and the top plate comprises a metal-based or silicon-based material. The apparatus further comprises a plurality of metal-based ***inductively coupled*** radio-frequency antennas disposed in the process chamber to provide linear lines.

The electric current flows in each of the antennas in ***one direction*** so that the directions of the respective electric currents in plural antennas are the same.

The induction electric fields due to the electric currents in the respective plural antennas are strengthened by each other on the basis of the interactions therebetween and the adjacent antennas are in parallel with each other on the same plane which is parallel to the object to be processed.

The process chamber has a first chamber wall having a plurality of antennas so that the antennas penetrate the first chamber wall into the inside of the process chamber.

The radio-frequency antennas disposed in the process chamber are covered with an insulating material so that the radio-frequency antennas do not directly contact the plasma.

The radio-frequency power is distributed by a distributor so that the radio-frequency power can be supplied into the process chamber from the plurality of antennas.

Further, in the present invention (*e.g.*, as shown in Fig. 1A), the direction of the electric current flowing in the adjacent antennas 10 is the same (in a portion thereof which is disposed inside the process chamber 1) so that the directions of the respective electric currents in the plural antennas 10 are the same. Based on the direction of the current, as shown in Fig. 1B, the inducted electric fields due to the electric currents in the respective plural antennas 10 disposed inside process chamber 1 are strengthened by each other, on the basis of the interactions therebetween. (Page 9, Line 31 – Page 10, Line 4, of the Present Specification).

Moreover, in the present invention, the radio-frequency power is distributed by a distributor so that the radio-frequency power can be supplied into the process chamber from the plurality of antennas. (See Fig. 1A). Therefore, the electric current flows in each of the antennas in one direction so that the directions of the respective electric currents in plural antennas are the same.

Taguchi discloses a general type of ICP source, wherein a plurality of one-turn antenna coils are disposed along the circumferential side wall of the plasma generating chamber. Fig. 6 of Taguchi shows the one-turn antenna coils and the coils are not linear.

Baldwin also discloses a general type of ICP source. The ICP coils are disposed on the top plate of a chamber so that they are directed from the center to the periphery of the top plate. For example, in Fig. 2 of Baldwin, the coils are branched from the center to the periphery of the top plate.

The Office Action acknowledges that neither Taguchi nor Baldwin discloses or suggests a plasma processing apparatus wherein a plurality of radio-frequency antennas are disposed in a process chamber, to provide linear lines, and the process chamber has a chamber wall having plural antennas penetrating the chamber wall. Thus, the Office Action cites Okabe as disclosing,

> [W]herein the antenna provides linear lines (4,5) so that the direction of electric currents in plural antennas are the same, induction electric fields due to the electric currents in the plural antennas are strengthened by each other on a basis of interactions therebetween and the adjacent antennas are in parallel with each other on the same plane which is parallel to the object to be processed (see abstract and Figures).

(Page 3).

Rather than disclosing "so that the direction of electric currents in plural antennas are the same", Okabe actually discloses that the directions of electric current in plural antennas (4, 5) are different from each other (see Fig. 1 of Okabe, reproduced below, with direction of electric current added) because the electrode the electrodes 4 and 5 are inserted from opposite sides of a processing chamber 1. Moreover, if the directions of the electrode 4 and 5 are the same, the thickness of a fabricated film would be non-uniform, as shown in Fig. 7 of Okabe. Accordingly, Okabe does not disclose "so that the direction of electric currents in plural antennas are the same" as recited in independent claim 13.

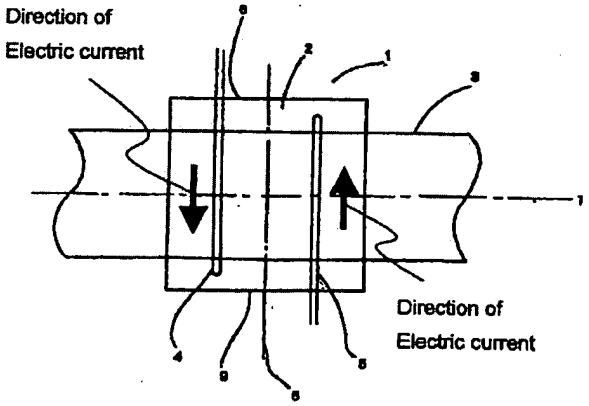


Fig 1

Rather than disclosing "induction electric fields due to the electric currents in the plural antennas are strengthened by each other on a basis of interactions therebetween", Okabe actually discloses an electric field due to a glow discharge. The electric field due to the glow discharge is formed between two electrodes as shown in Fig. A.

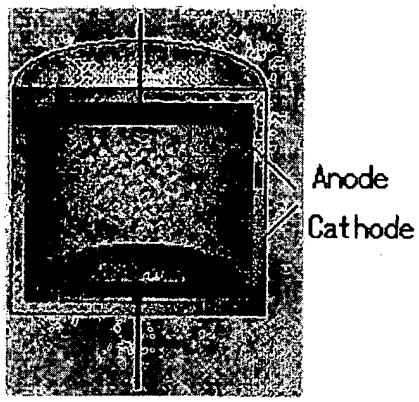
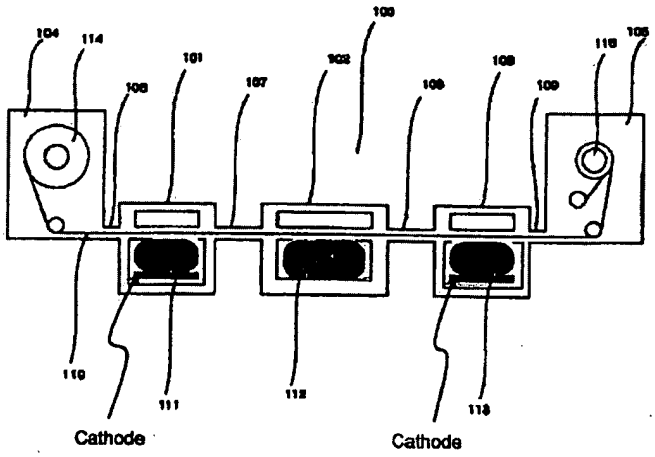


Fig. A

In Fig. 1 of Okabe, anode electrode (4, 5) are shown, and cathode electrodes are shown in Fig. 4 (reproduced below, with indication of cathodes added).



On the other hand, the present invention relates to inductively coupled plasma as shown in Fig. B.

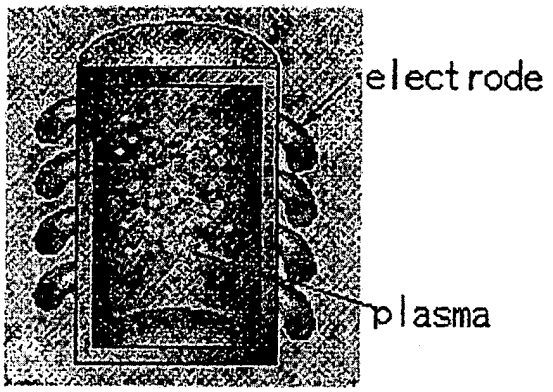


Fig. B

As shown in Fig. B, plasma is formed by the induction electric fields due to the electric current of a plurality of electrode having the same direction as each other. Although the electrodes in Fig. B are curved, the principle is the same as the linear electrode as shown in the present invention.

Based on the above structure, the present invention can provide a plasma processing apparatus using ***Inductively Coupled Plasma*** (ICP) that can generate high-density plasma with high efficiency, even in the case of the treatment of an object to be processed having a large area. (Page 18, lines 4-8, of the Present Specification). The ICP method is based on Fleming's left-hand rule. When current flows through an electrode (antenna), a magnetic field is formed around the current and an electric field is formed perpendicular to the magnetic field. Namely, the direction of the current is very important.

Accordingly, Okabe does not disclose "induction electric fields due to the electric currents in the plural antennas are strengthened by each other on a basis of interactions therebetween" as recited in independent claim 13.

The Office Action cites Glukhoy as disclosing,

> [T]hat the antenna disposed in the process chamber is covered with an insulating material 64 so that the radio-frequency antenna does not directly contact the plasma, wherein an insulating fluid is circulated between the antenna and the insulating material using tubes 82 (see paragraph 0035-0036), and wherein the process chamber has a second chamber wall opposed to the first chamber

> wall, and each antenna penetrates the first chamber wall and the second chamber wall.

(Page 4). However, Applicants point out that contrary to the presently claimed plasma processing apparatus wherein a plurality of radio-frequency antennas are disposed in a process chamber, the electric current flows in each of the antennas in one direction so that the directions of the respective electric currents in plural antennas are the same, and the induction electric fields due to the electric currents in the respective plural antennas are strengthened by each other on the basis of the interactions therebetween, Glukhoy discloses a plurality of radio-frequency antennas flowing electric current in different directions from each other in the plurality of the antennas. (See Fig. 3).

The Office Action cites Ueda as disclosing "wherein said radio-frequency power is distributed by a distributor (14,15) so that the radio-frequency power can be supplied into the process chamber from said plurality of antennas (see fig. 3 and its description)." (Page 4).

Ueda discloses a structure in which power is supplied to a plurality of electrodes 22A to 22E. However, the power is supplied to a "power supplying side" of the electrodes. Therefore, the directions of an electric current of the "power supplying side" and an electric current of the "grounded side" differ from each other. If the structure of Ueda were to be combined with the proposed combination of Taguchi, Baldiwn, Okabe, and Glokhoy, the directions of the plurality of the electrodes would differ from each other and this would prohibit strengthening inducted electric fields.

Applicants respectfully submit that the proposed combination of the apparatus of Taguchi (having a plurality of one-turned coils), Baldwin (having ICP coils), Okabe (using the glow discharge method), and Glokhoy (having a plurality of antennas with electric current flowing in different directions from each other) would result in a plasma process apparatus using the glow discharge method and having a plurality of antennas with coils in which electric current flows in different direction from each other.

Accordingly, Applicants further respectfully submit that it would ***not*** have been obvious to one of ordinary skill in the art to obtain the presently claimed plasma processing apparatus by combining the apparatus of Taguchi, Baldiwn, Okabe, and Glokhoy. For example, in the presently claimed plasma processing apparatus, *inter alia*, (i) a plurality of metal-based inductively coupled radio-frequency antennas are disposed in the process chamber to provide linear lines, (ii) electric current flows in each of the antennas in one direction ***so that the directions of the respective electric currents in plural antennas are the same***, (iii) ***induct ion electric fields due to the electric currents in the plural antennas are strengthened by each other on a basis of interactions therebetween***; and (iv) the adjacent antennas are in parallel with each other on the same plane which is parallel to the object to be processed.

The secondary references of Holland, Takagi, and Grimbergen fail to remedy the deficiencies of Taguchi, Baldwin, Okabe, Glukhoy, and Ueda, as noted above. The Office Action cites Holland and Takagi merely for disclosure of varying the thickness or diameter of a radio frequency antenna and Grimbergen merely for disclosure of a measuring device which is disposed in the top of the chamber so as to monitor the state of the generated plasma and a top plate which has a plurality of apertures for passing a gas to be supplied to the process chamber.

Applicants respectfully submit that one of ordinary skill in the art neither could, nor would, have accomplished the proposed combinations and that the results of the proposed combinations would not have been predictable to one of ordinary skill in the art, for at least the reasons noted above. Applicants further respectfully submit that even if one of ordinary skill in the art could have accomplished the proposed combinations, none of the proposed combinations discloses or suggests all of the present claim limitations. In particular, none of the proposed combinations discloses or suggests, *inter alia*, electric current flows in metal-based inductively coupled radio-frequency antennas in one direction so that the directions of respective electric currents in plural antennas are the same

and induction electric fields due to the electric currents in the plural antennas are strengthened by each other on a basis of interactions therebetween. Accordingly, claims 17, 19, 21 and 22, which depend either directly or indirectly from claim 13, are patentable at least for the reasons that claim 13 is patentable.

Reconsideration and withdrawal of the rejection of: **(1)** claims 13, 16, 19, 23, 25, and 26 over Taguchi in view of Baldwin, Okabe, Glukhoy, and Ueda, **(2)** claim 17 over Taguchi in view of Baldwin, Okabe, Glukhoy and Ueda and further in view of Holland or Takagi, and **(3)** claims 21 and 22 under 35 U.S.C. § 103(a) over Taguchi in view of Baldwin, Okabe, Glukhoy and Ueda and further in view of Grimbergen, are respectfully requested.

In view of the foregoing, the application is respectfully submitted to be in condition for allowance, and prompt favorable action thereon is earnestly solicited.

If there are any questions regarding this response or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket # 101249.52602US).

Respectfully submitted,

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